DIRECTIONS

177132 | Issue 5

C1-270/2
LTECC

Rec. 6/30/69 Copy #1

8693-2

TEMPERATURE POTENTIOMETER

PROPERTY OF DEPT. C-270
METROLOGY L.A.B.
DO NOT REMOVE
FROM AREA
11-02-79

LEEDS & NORTHRUP

CONTENTS

Section		Page
1.	Introduction	3
2.	Specifications	3
3.	Control Panel Features	4
4.	Explanation of Operation	5
	A. Standardization	5
	B. Measurement	6
	C. Checking	8
5.	Operating Instructions	8
	A. Precautions	8
	B. Adjust Galvanometer Zero	8
	C. Standardize Circuit	8
	D. Measure Temperature	9
	E. Measure Millivoltage	9
	F. Check Similar Potentiometer-Type Instruments	12
6.	Range Change Instructions	15
7.	Calibration	18
	A. Millivolt Range Circuit	18
	B. Temperature Range Circuit	19
8.	Measuring Slidewire Contact Force Adjustments	20
9.	Maintenance	21
	A. Battery	21
	B. Cleaning the Measuring Slidewires	21
	C. Standard Cell	22
	D. Galvanometer	22
	E. Measuring Slidewire Contact Assemblies	23
	F. Scale Window	23
10.	Replacement Parts and Auxiliary Equipment	23
	A. Replacement Parts	23
	B. Auxiliary Equipment	24
	Appendix	25

8693

TEMPERATURE POTENTIOMETER

1. INTRODUCTION

The 8693 Temperature Potentiometer is a portable, battery-operated, double-range potentiometer designed for general plant and laboratory use. The instrument ranges are supplied according to the user's specifications, and include either two temperature ranges reading directly in degrees, one temperature and one mv range, or two mv ranges. Automatic reference-junction compensation is included with all temperature ranges. The instrument is designed for use with thermocouples or other emf sources. It can also serve as a source of calibrated voltage for checking other potentiometer-type instruments.

A general view of the potentiometer is shown in Fig. 1 and a detailed view of the control panel is shown in Fig. 2.

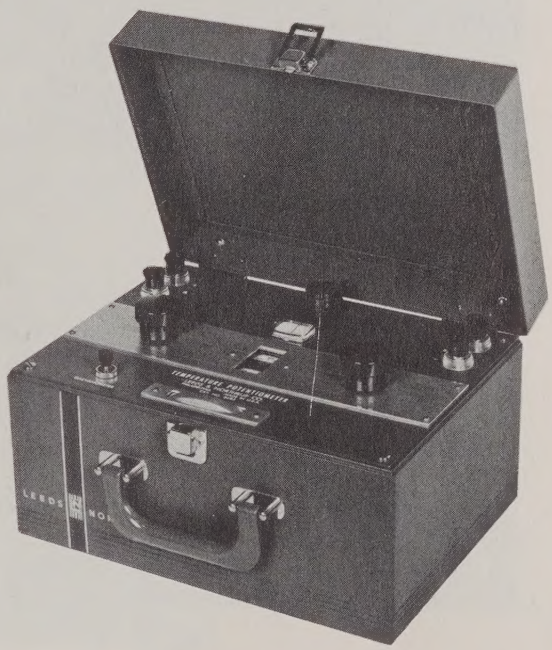


Fig. 1—8693 Portable Temperature Potentiometer.

2. SPECIFICATIONS

LIMIT OF ERROR: ±0.2% of range span for all standard ranges when external resistance does not exceed 50 ohms.

GALVANOMETER*:

Sensitivity: 1.0 microampere per scale division (equivalent to 45 microvolts per scale division for total circuit resistance of R_C + CDRX)

Galvanometer Resistance (R_C): 35 ohms

External Critical Damping Resistance (CDRX): 35 ohms

BATTERY: 1.5 volts

*Sensitivity at least as high as stated - other characteristics within ±20%.

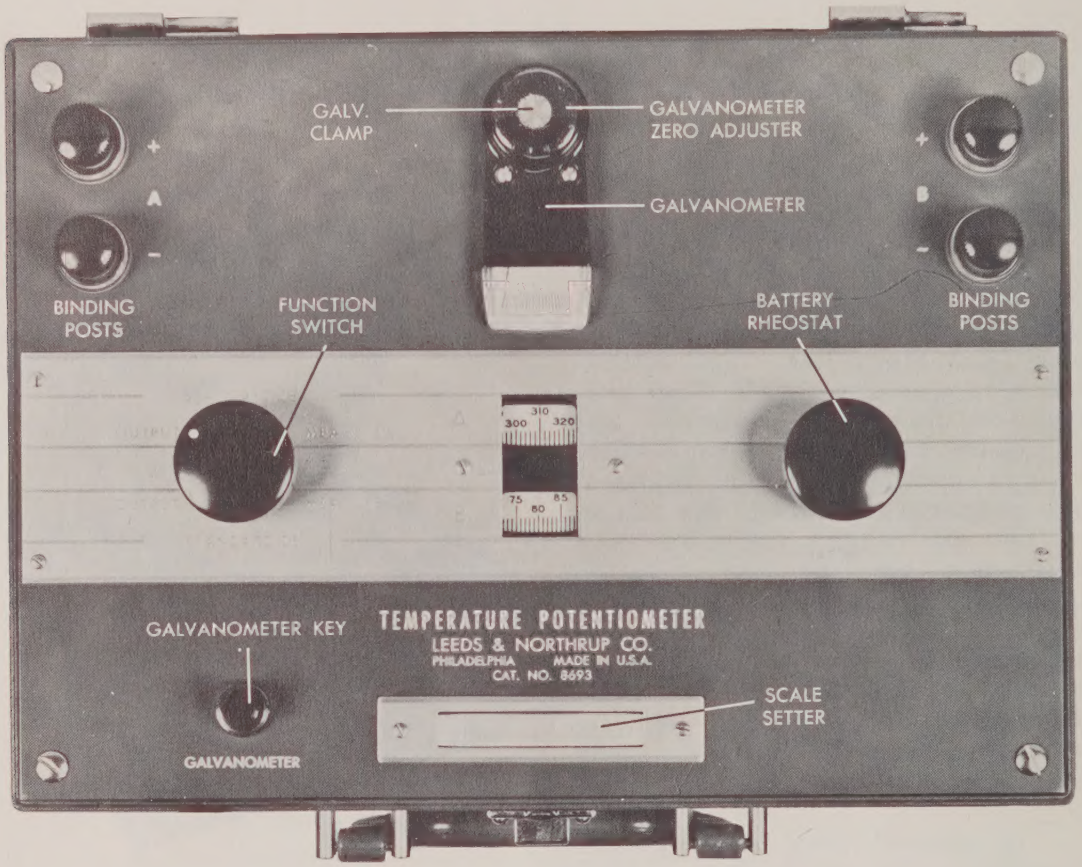


Fig. 2—Control panel of 8693 Portable Temperature Potentiometer.

3. CONTROL PANEL FEATURES

FUNCTION SWITCH

MEASURE A (or B) position - permits making temperature or millivolt measurements with scale setter on A (or B) range respectively

STANDARDIZE A (or B) position - permits adjustment of battery current by battery rheostat to standardize A (or B) potentiometer circuit respectively

OUTPUT A (or B) position - provides calibrated voltage at A (or B) binding posts respectively for checking potentiometer-type instruments

BATTERY RHEOSTAT

Adjusts battery current for standardizing potentiometer circuits

for both ranges

SCALE SETTER

Adjusts position of measuring slidewires and scales in relation to fixed positions of measuring slidewire contacts and scale indices

GALVANOMETER KEY

Up position - opens galvanometer circuit

Down position - closes galvanometer circuit - key can be locked in this position by turning it clockwise

BINDING POSTS

A (or B) - for attaching connections from thermocouples, other emf sources, or potentiometer-type instruments to be checked

GALVANOMETER

Indicates unbalance between potentiometer circuits and measured emf's

SCALES

Indicate values of temperature or emf being measured (or output on "Output" position)

4. EXPLANATION OF OPERATION

As shown schematically in Fig. 7, the 8693 Temperature Potentiometer fundamentally consists of two separate two-branch potentiometer circuits - one for the A range and the other for the B range. Both circuits are balanced manually by the rotation of the scale setter that extends through the control panel. This setter is coupled mechanically to the drum on which the slidewires and scales are mounted. Both circuits operate identically. The A range circuit operates as follows.

A. Standardization

The circuit is arranged with two branches of equal resistance to which current is supplied by battery BA. The magnitude of the current is controlled by battery rheostat S3 which is in series with the battery. The circuit is designed to provide a battery drain of 5 ma with the current dividing equally between the two branches. When the current in each branch is adjusted to 2.5 ma, the circuit is standardized.

Standardization is effected by placing the function switch in the standardize position and by depressing the galvanometer key. This connects galvanometer GA and shunt resistor R1 (which critically damps the

galvanometer) into a loop which includes resistor C and the standard cell. The standard cell emf is always equal to 1.0195 volts absolute (within 0.1%). Resistor C is chosen to be 407.8 ohms so that with 2.5 ma flowing, the drop across C is 0.0025 x 407.8 or 1.0195 volts.

If the current flowing through C is equal to 2.5 ma, the two opposing voltages of the loop balance each other and no current flows in the loop. If the current is not exactly 2.5 ma, the resultant voltage unbalance causes an error current to flow through the galvanometer, thereby causing it to deflect from its zero (null balance) position. This unbalance is corrected by adjusting the battery rheostat until the galvanometer balances. This indicates that 2.5 ma is flowing through C and that the two opposing voltages are balanced. Thus standardization is accomplished by the null-balance method.

Since the battery is connected in either the A or B range circuit at all times, there is a continuous current drain from it. Thus the battery emf will decrease gradually. This decrease is corrected by standardizing the curcuit before each series of measurements or checks and also at regular intervals depending upon the stability of the battery.

As the battery emf decreases, repeated standardizations cause more and more of the battery-rheostat resistance to be adjusted out of the circuit. When all the resistance has been adjusted out (that is, the battery rheostat is at the end of its travel), the currents in the circuit can no longer be standardized unless the battery is replaced with a fresh one.

B. Measurement

When measuring temperature or millivoltage, the function switch is placed in the measure position and the galvanometer key is depressed. This connects the thermocouple or emf source to the circuit through the galvanometer. The unknown temperature or millivoltage is then measured by rotating the scale setter in the proper direction until the galvanometer is balanced. Thus the emf from the thermocouple or other source is balanced by the potential difference existing between the measuring slidewire contact and the junction of resistors D and C. The temperature or millivoltage is then indicated under the scale index.

Measuring slidewire S, trimmer rheostat S2, and resistors G, K, and D have been selected to make the potential difference between the measuring slidewire contact and the junction of resistors D and C vary through the measuring range. Resistor B has been selected to make the total resistance of the upper branch equal to that of the lower branch.

(1) Temperature Ranges

Automatic reference-junction compensation is provided for temperature ranges. To provide this compensation, resistor D is temperature sensitive and the reference (cold) junction of the thermocouple is located inside resistor D which is mounted on the circuit panel. This is

accomplished by using a D resistor composed of copper and nickel, by connecting the thermocouple to the binding posts with extension wire*, by using binding post studs composed of material having thermo-electric characteristics similar to those of the extension wire, and by connecting the binding posts to the reference-junction compensating points with extension wire. The circuit is so designed that the reference-junction compensating points are located inside resistor D, thereby actually extending the thermocouple to the inside of resistor D.

This resistor, over a limited range, has a temperature characteristic that matches that of the thermocouple being used. That is, with constant 2.5 ma current flowing through D, any change in the temperature of D produces a corresponding change in the potential drop across D. The change in potential drop across D for a given temperature variation is equal to the change in the output of the thermocouple subjected to the same variation. It causes the potential difference between the measuring slidewire contact and the junction of resistors D and C to vary automatically. Since resistor D surrounds the reference-junction compensating points (reference junction of the thermocouple), the resistor is affected by the same temperature variations that affect the thermocouple's reference junction. Resistor D therefore compensates for any change in the thermocouple's reference-junction temperature.

The composition and resistance of resistor D depends upon the type of thermocouple and the average operating temperature at the reference-junction compensating points. Therefore, the proper value of D, as determined by the above conditions, was used to compute the total lower-branch resistance of the circuit. Since no compensation would be required if the reference junction were at the reference temperature** - that is, 32 F (0 C) - the resistance value of D at 32 F (0 C) must be balanced out of the circuit. This was done by including this value in resistor G.

(2) Millivolt Ranges

Automatic reference-junction compensation is not included in the millivolt range circuits. Therefore in such circuits, resistor D is not temperature sensitive, the binding posts have copper studs, and no reference-junction compensating points are provided. Such circuits measure directly the millivolt output of the thermocouple or emf source connected to them.

---

* Wire having thermo-electric characteristics similar to those of the thermocouple.

** For a given type of thermocouple the millivolt outputs corresponding to various hot junction temperatures are given in a table listed in Directions 077989, "Conversion Tables for Thermocouples". These tabular values are based upon the use of a thermocouple whose reference (cold) junction is at the reference temperature specified in the table. This temperature is usually 32 F (0 C).

C. Checking

Checking of similar potentiometer-type instruments is accomplished by placing the function switch in the output position (thereby shorting out the galvanometer), by rotating the scale setter until the desired temperature or millivoltage is indicated under the scale index, and by depressing the galvanometer key. The reading on the instrument being checked should then be identical or equivalent to the potentiometer scale setting within the combined adjustment accuracy of both instruments.

5. OPERATING INSTRUCTIONS

The potentiometer is shipped from the factory completely prepared for immediate use. No loose parts are supplied, as all parts, including the battery, are contained in the case.

A. Precautions

To protect the galvanometer whenever the potentiometer is not being used, place the FUNCTION switch in either of the OUTPUT positions and unlock the GALVANOMETER key. *

The potentiometer contains a standard cell. It is an unsaturated cell and should be used where the ambient temperature remains between 32 F (0 C) and 122 F (50 C).

When the potentiometer will be stored or inoperative for months, remove the battery to avoid possible damage from leakage.

B. Adjust Galvanometer Zero *

To adjust the galvanometer zero, place the FUNCTION switch in one of the STANDARDIZE positions. Make certain that the GALVANOMETER key is in its UP position. Then turn the galvanometer zero adjuster until the galvanometer pointer is at zero.

C. Standardize Circuit

To standardize either circuit—that is, to adjust the current in the circuit—proceed as follows:

Place the FUNCTION switch in the pertinent STANDARDIZE position.

Check the galvanometer zero, and if necessary, adjust it.

Depress or lock down the GALVANOMETER key. If the galvanometer pointer deflects from its zero (null balance) position, adjust the BATTERY rheostat until the galvanometer pointer balances at its zero position.

---

* The moving element may be clamped with the thumbscrew in the center of the zero adjuster cap. Turn clockwise to clamp, counterclockwise to unclamp (full travel about 3-1/2 turns).

TABLE I—EXTENSION WIRE

THERMOCOUPLE		EXTENSION WIRE	
+	−	+	−
Iron	Constantan	Iron	Constantan
Copper	Constantan	Copper	Constantan
Chromel	Alumel	Chromel Copper Iron	Alumel Constantan Cupronel
Plat. Rhodium	Platinum	Copper	#11 Alloy

Standardize the circuit in use before each initial measurement or check, and at regular intervals depending upon the stability of the battery.

D. Measure Temperature

To measure temperature with a scale calibrated in degrees, proceed as follows:

- Connect the thermocouple to the pertinent BINDING POSTS with the proper extension wire as determined from Table I. Make sure that the polarities of the connections are correct.

- Standardize the circuit.

- Place the FUNCTION switch in the pertinent MEASURE position, depress or lock down the GALVANOMETER key, and then rotate the SCALE setter until the galvanometer is balanced. Now release or unlock the GALVANOMETER key and read the temperature under the pertinent scale index.

E. Measure Millivoltage

Millivolt range circuits can be used to measure the millivolt outputs of thermocouples or other emf sources.

(1) Output of Thermocouple

To measure the output of a thermocouple when using a millivolt scale, proceed as instructed in either of the following methods.

(a) Ice Bath Method

In this method the thermocouple is connected to the BINDING POSTS as shown in Fig. 3. The junctions formed at the connections of the copper and extension wires are held at 32 F (0 C). In effect the circuit constitutes a thermocouple with its reference (cold) junction at 32 F (0 C).

To make the measurement, proceed as follows:

- Connect the thermocouple to the pertinent BINDING POSTS

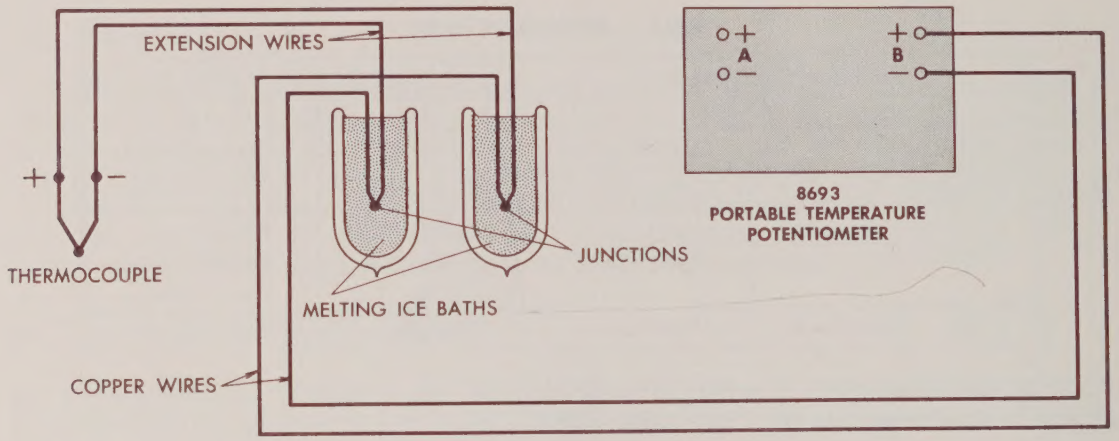


Fig. 3—Connections for measuring output of thermocouple using ice bath method.

as shown in Fig. 3. Use extension wire as determined from Table I. Make sure that the polarities of the connections are correct.

- Use well compacted melting ice baths to maintain the temperature of the copper-to-extension wire junctions. It is permissible to use a single ice bath, provided the junctions are electrically insulated. A coating of paraffin will provide the required insulation.

- Immerse the junctions at least four inches in the ice baths and allow time for them to reach ice bath temperature.

- Standardize the circuit in use.

- Place the FUNCTION switch in the pertinent MEASURE position, depress or lock down the GALVANOMETER key, and then rotate the SCALE setter until the galvanometer is balanced. Now release or unlock the GALVANOMETER key and read the millivolts under the pertinent scale index.

To convert the above millivolt reading into a temperature reading equivalent to the temperature at the thermocouple's measuring junction, determine the temperature corresponding to the above millivoltage from the proper conversion table in Directions 077989, "Conversion Tables For Thermocouples". This will be the temperature detected by the thermocouple.

(b) Thermometer Method

In this method the thermocouple is connected to the binding posts with either copper or extension wire. If copper wire is used, the reference junction is at the junction of the copper and thermocouple wires; if extension wire is used, the reference junction is at the binding posts.

To make the measurement, proceed as follows:

- Connect the thermocouple to the pertinent BINDING POSTS with either copper wire or extension wire as determined from Table I. Make sure that the polarities of the connections are correct.

- Standardize the circuit.

- Place the FUNCTION switch in the pertinent MEASURE position, depress or lock down the GALVANOMETER key, and then rotate the SCALE setter until the galvanometer is balanced. Now release or unlock the GALVANOMETER key and read the millivolts under the pertinent scale index.

To convert the above millivolt reading into a temperature reading equivalent to the temperature at the thermocouple's measuring junction, proceed as follows:

- Measure the temperature at the thermocouple's reference junction with a suitable thermometer*.

- Determine the millivoltage corresponding to the above temperature from the proper conversion table in Directions 077989.

- Add algebraically the millivoltage corresponding to the reference junction temperature to the millivolt reading of the potentiometer.

- Determine from the proper conversion table the temperature corresponding to the above resultant millivoltage. This will be the temperature detected by the thermocouple.

For example: Assume that the thermocouple is composed of Chromel and Alumel and that its output as measured by the potentiometer is 11.63 mv. Also assume that the temperature at the thermocouple's reference junction as measured by a thermometer is 86 F. Refer to the conversion table for Chromel vs. Alumel thermocouples, based on a reference-temperature of 32 F, for the millivoltage corresponding to 86 F. This is found to be 1.20 mv. Now add algebraically the 11.63 mv to the 1.20 mv. This equals 12.83 mv. Again refer to the conversion table for the temperature corresponding to 12.83 mv. This is found to be 599 F and is the temperature detected by the thermocouple.

(2) Output of Other Emf Source

To measure the millivolt output of an emf source when using a millivolt scale, proceed as follows:

*The thermometer accuracy should be such that the accuracy of the measurement is not adversely affected by the use of this thermometer.

- Connect the source to the pertinent BINDING POSTS with copper wire. Make sure that the polarities of the connections are correct.

- Standardize the circuit.

- Place the FUNCTION switch in the pertinent MEASURE position, depress or lock down the GALVANOMETER key, and then rotate the SCALE setter until the galvanometer is balanced. Now release or unlock the GALVANOMETER key and read the millivolts under the pertinent scale index.

F. Check Similar Potentiometer-Type Instruments

The potentiometer can be used to check similar potentiometer-type instruments, such as recorders, controllers, and indicators. If the potentiometer has a temperature range, it can be used to check instruments having automatic reference-junction compensation and temperature ranges within the range of the potentiometer. If the potentiometer has a millivolt range, it can be used to check instruments having millivolt ranges or, when used with the proper conversion tables, it can be used to check instruments having automatic reference-junction compensation and temperature ranges within the equivalent millivolt range of the potentiometer.

(1) With Temperature Circuit

To check a recorder or controller having a temperature range with automatic reference-junction compensation, proceed as follows:

- Stop the recorder or controller and disconnect the thermocouple(s) from the thermocouple terminals or connectors. Make sure that the pen, temperature index, or print wheel are properly aligned as directed in the direction book of the recorder or controller.

- Connect the pertinent BINDING POSTS on the potentiometer to the proper thermocouple terminals or connectors on the recorder or controller with extension wire as determined from Table I. Be sure that the polarities of the connections are correct.

- Standardize the instrument being checked as directed in its direction book. Also standardize the potentiometer circuit.

- Place the FUNCTION switch in the pertinent OUTPUT position, rotate the SCALE setter until the desired check temperature is indicated under the pertinent scale index, and lock down the GALVANOMETER key.

- Start the recorder or controller and allow it to reach a balance. The pen, scale pointer, or print wheel should then register the same temperature as that set on the potentiometer within the combined adjustment accuracy of both instruments.

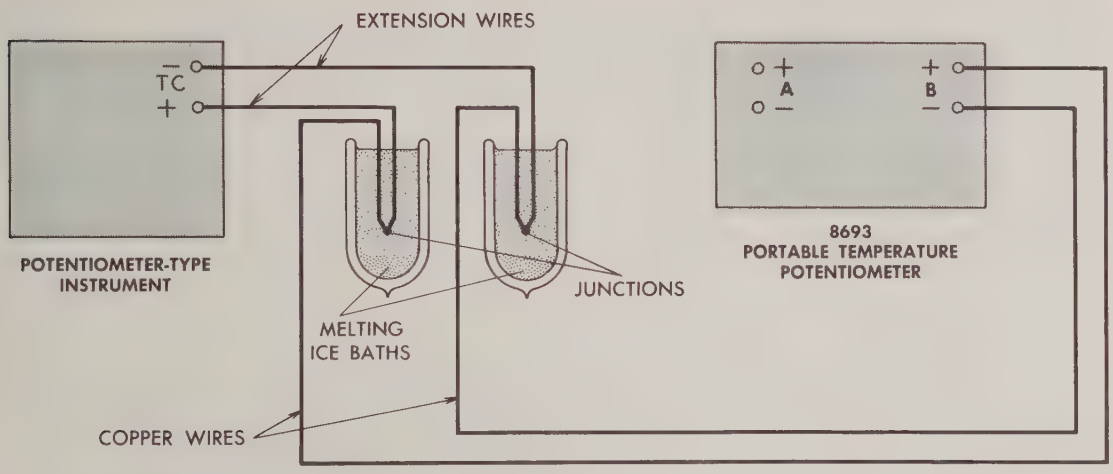


Fig. 4—Connections for checking potentiometer-type instrument using ice bath method.

To check manually-operated indicators, follow the same procedures described in the previous paragraphs. However the main dial of the indicator being checked must be turned until its galvanometer balances at zero (null balance). The reading on the main scale of the indicator then should check with the temperature setting of the potentiometer within the combined adjustment accuracy of both instruments.

NOTE: This is a check on the instrument only. If there is thermocouple trouble, replace the thermocouple or make further checks on it to determine its error.

(2) With Millivolt Range Circuit

To check potentiometer-type instruments having millivolt ranges without automatic reference-junction compensation, proceed as follows:

- As directed in the direction book of the instrument being checked, adjust the instrument's galvanometer to its mechanical zero position. Also standardize the instrument.

- Connect the potentiometer's pertinent BINDING POSTS to the proper binding posts or terminals of the instrument. Use copper wire to do this. Make sure that the polarities of the connections are correct.

- Standardize the potentiometer circuit.

- Place the FUNCTION switch in the pertinent OUTPUT position, rotate the SCALE setter until the desired millivoltage is indicated under the pertinent scale index, and lock down the GALVANOMETER key.

- Allow the instrument to operate to a galvanometer balance or,

if it is a manually operated instrument, turn its main dial until its galvanometer balances at zero (null balance). The reading on the main scale of the instrument should then check with the millivolt setting of the potentiometer within the combined adjustment accuracy of both instruments.

To check potentiometer-type instruments having temperature ranges with automatic reference-junction compensation, proceed as instructed in either of the following methods.

(a) Ice Bath Method

- As directed in the direction book of the instrument being checked, adjust the instrument's galvanometer or balancing system to its mechanical zero position. Also standardize the instrument.

- Connect the pertinent BINDING POSTS of the potentiometer to the proper thermocouple binding posts or terminals of the instrument as shown in Fig. 4. Use extension wire as determined from Table I. Make sure that the polarities of the connections are correct.

- Use well compacted melting ice baths for maintaining the temperature of the copper-to-extension wire junctions. It is permissible to use a single ice bath, provided the junctions are electrically insulated. A coating of paraffin will provide the required insulation.

- Immerse the junctions at least four inches in the ice baths and allow time for them to reach ice bath temperature.

- Standardize the potentiometer circuit and place the FUNCTION switch in the pertinent OUTPUT position.

- From the proper conversion table in Directions 077989, determine the millivolt equivalent of the temperature at which it is desired to check the instrument.

- Rotate the SCALE setter until the above millivolt value is indicated under the pertinent scale index. Then lock down the GALVANOMETER key.

- Allow the instrument to operate to a balance or, if it is a manually-operated instrument, turn its main dial until its galvanometer balances at zero (null balance).

The temperature reading on the main scale of the instrument being checked should then be correct within the combined adjustment accuracy of both instruments.

(b) Thermometer Method

- As directed in the direction book of the instrument being

checked, adjust the instrument's galvanometer or balancing system to its mechanical zero position. Also standardize the instrument.

- Connect the potentiometer's pertinent BINDING POSTS to the proper thermocouple binding posts or terminals of the instrument being checked. Use extension wire as determined from Table I. Make certain that the polarities of the connections are correct.

- Standardize the potentiometer circuit and place the FUNCTION switch in the pertinent OUTPUT position.

- From the proper conversion table in Directions 077989, determine the millivoltage corresponding to the temperature at which it is desired to check the instrument.

- Measure the temperature at the binding posts of the potentiometer with a suitable thermometer*.

- From the same conversion table determine the millivoltage corresponding to the temperature at the binding posts.

- Subtract algebraically the millivoltage corresponding to the temperature at the binding posts from the millivoltage corresponding to the temperature at which it is desired to check the instrument.

- Rotate the SCALE setter until the above resultant millivoltage is indicated under the pertinent scale index. Then lock down the GALVANOMETER key.

- Allow the instrument to operate to a balance or, if it is a manually-operated instrument, turn its main dial until its galvanometer balances at zero (null balance).

The temperature reading on the instrument being checked should then be correct within the combined adjustment accuracy of both instruments.

6. RANGE CHANGE INSTRUCTIONS

To change either of the present ranges of the potentiometer to a new range, proceed as follows:

- Carefully remove the control panel assembly from the case. Do this by loosening the four panel mounting screws sufficiently to disengage the fasteners. Rest the assembly face down on a suitable surface such as a work bench or table. Take care not to scratch or damage the

*The thermometer accuracy should be such that the accuracy of the measurement is not adversely affected by the use of this thermometer.

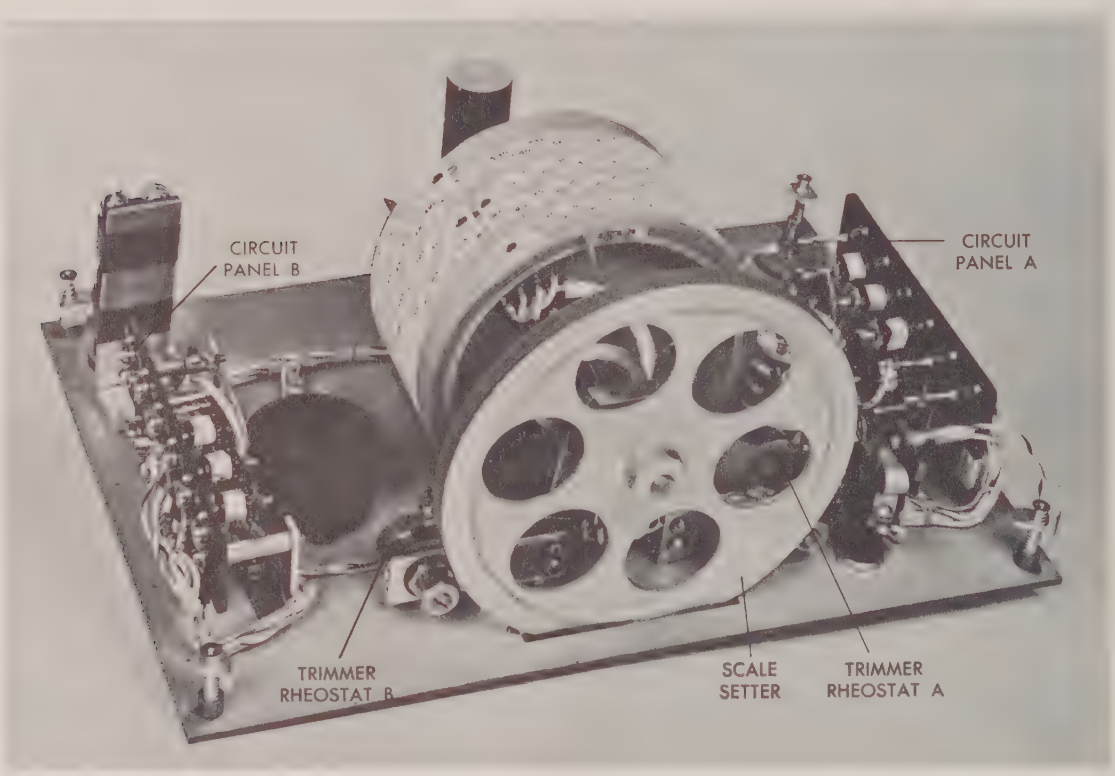


Fig. 5—Underside of control panel assembly (viewed from "knurled wheel" side of assembly).

surfaces of the knobs, binding posts, etc. Figs. 5 and 6 show the underside of the control panel assembly.

- Disconnect from the pertinent circuit panel the two leads that are attached to the binding post studs. Do this by loosening the bottom nut on each binding post.

- If a new stud(s) is supplied with the range change parts, replace the present stud(s) with the new one(s). To do this, first remove the two nuts from the binding post to free the stud. Then remove the cap from the stud.

> CAUTION: WHEN REPLACING THE BINDING POST STUD ON WHICH THE STANDARD CELL ASSEMBLY IS MOUNTED, TAKE CARE NOT TO DAMAGE THE STANDARD CELL AS THE ASSEMBLY IS FREED FROM ITS MOUNTING IN THE PROCESS.

- Mount the new stud(s) in the binding post(s) by reversing the above procedure. Make certain that the standard cell assembly, if freed from its mounting, is remounted properly.

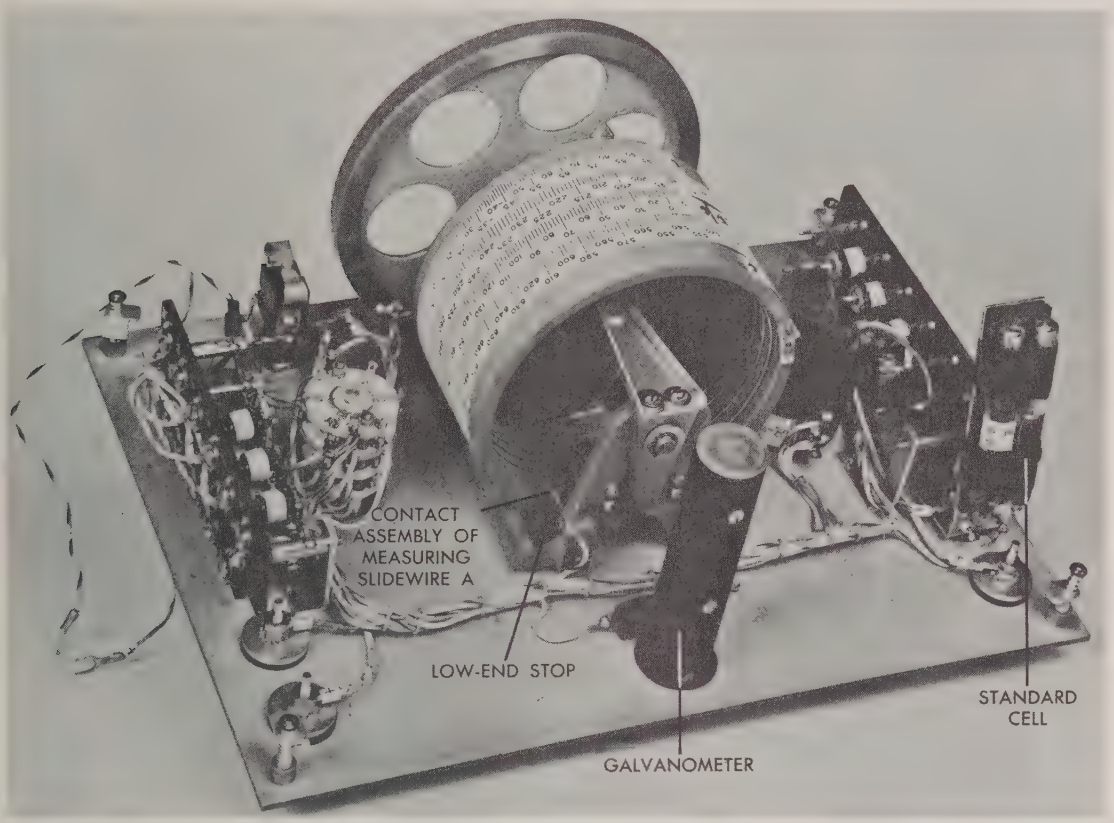


Fig. 6—Underside of control panel assembly (viewed from "galvanometer" side of assembly).

- Remove the disconnected circuit panel* and replace it with the new one*. To facilitate this, all terminal lugs on the wiring leads to and from the removed circuit panel are suitably marked to correspond to the markings of the terminals on the new circuit panel and to the markings of the binding posts.

- Remove the pertinent scale from the slidewire drum by removing the two screws that secure the scale to the drum.

CAUTION: WHEN REMOVING THE SCALE, TAKE CARE NOT TO DAMAGE THE HAIRLINE INDICES OF THE SCALES.

- Mount the new scale, making sure that its mounting conforms to the original mounting arrangement. This is facilitated by proceeding

*The resistor connected between terminals 5 and 6 of the circuit panels is not used in the potentiometer circuits associated with the panels. Therefore disregard its presence.

as follows:

– Rotate the slidewire drum to its low-end stop. (This stop is mounted on the galvanometer side of the drum.) Then reverse the rotation until the tapped holes for mounting the scales are accessible.

– Carefully slide the new scale (face down with its low end towards the function switch) under the slidewire drum.

CAUTION: DO NOT KINK OR DAMAGE THE SCALE AND DO NOT DAMAGE THE HAIRLINE INDICES OF THE SCALES.

– Attach the low end of the scale to the tapped hole that is in line with the low-end mounting screw of the other scale. Use one of the removed screws to do this. Now wrap the scale around the drum by rotating the drum towards its high-end stop. Make sure that the scale butts against itself and is tightly wrapped around the drum. Fasten the high (slotted) end of the scale to the drum with the remaining screw. If there is any slack in the scale, take it up.

7. CALIBRATION

This section outlines the proper procedures for checking the calibration of the potentiometer circuits. Such a check is necessary whenever the instrument's range has been changed, the slidewire assembly disturbed or removed, or the contact assembly disturbed or replaced. The user may also wish to check the calibration of the potentiometer circuits periodically.

To check and, if necessary, adjust the calibration of either circuit proceed as follows: Make all adjustments and settings and take all readings as accurately as possible.

A. Millivolt Range Circuit

(1) Standardize the circuit and then place the FUNCTION switch in the pertinent OUTPUT position.

(2) Carefully remove the control panel assembly from the case by loosening the four panel screws sufficiently to disengage the fasteners. Rest the assembly on a suitable surface so that it leans on the scale setter. Do not disconnect any wiring.

(3) Connect a source of calibrated voltage to the pertinent BINDING POSTS with copper wire.

(4) Rotate the SCALE setter until the low-end division of the pertinent scale is under its scale index.

(5) Apply a millivolt value equivalent to the low-end value of the scale.

(6) Now place the FUNCTION switch in the pertinent MEASURE position and lock down the GALVANOMETER key.

(7) Adjust the position of the pertinent slidewire contact on its slidewire until the galvanometer balances. To do this loosen the screws that secure the contact assembly to the slidewire casting, adjust the contact position as required, and then tighten the screws to secure the contact assembly in place. Make sure that the contact bears against the slidewire with a force of 2 to 3 ounces. (Refer to Section 8 for instructions for measuring and adjusting the contact force.)

(8) Rotate the SCALE setter until the high-end division of the scale is under the scale index.

(9) Now apply a millivolt value equivalent to the high-end value of the scale.

(10) Loosen the locknut on the pertinent trimmer rheostat (S2 or S4) and adjust the rheostat until the galvanometer balances.

(11) Repeat Steps 4 to 10 inclusive. Then tighten the locknut on the trimmer rheostat to secure its adjustment.

(12) Other points on the scale may now be checked by proceeding in a manner similar to that described above. Do not disturb the position of the slidewire contact or the adjustment of the trimmer rheostat when making these checks. The limit of error of these checks should not exceed ±0.2% of the circuit's range span.

(13) Finally place the FUNCTION switch in the OUTPUT position, unlock the GALVANOMETER key, remove the connections from the BINDING POSTS, and remount the control panel assembly in the case. Tighten the four panel mounting screws to engage the fasteners.

B. Temperature Range Circuit

Temperature range circuits may be checked by either of the following methods.

(1) Thermometer Method

Proceed as directed in the calibration instructions for the millivolt range circuit except determine the millivolt values required for Steps 5, 9, and 12 by proceeding as follows:

Measure the temperature at the potentiometer binding posts with a suitable thermometer*.

*The thermometer accuracy should be such that the accuracy of the measurement is not adversely affected by the use of this thermometer.

From the proper conversion table in Directions 077989 (32 F or 0 C), determine the millivoltage corresponding to the temperature at the binding posts.

From the same table, determine the millivoltage corresponding to the low-end temperature value of the scale.

Subtract algebraically the millivoltage corresponding to the temperature at the binding posts from the millivoltage corresponding to the low-end temperature value of the scale. The resultant millivoltage is the millivolt value required for Step 5.

To determine the millivolt values for Steps 9 and 12, proceed in a manner similar to that described above.

(2) Ice Bath Method

Proceed as directed in the calibration instructions for the millivolt range circuit except make the connections required for Step 3 and determine the millivolt values required for Steps 5, 9, and 12 by proceeding as follows:

Connect the source of calibrated voltage to the pertinent BINDING POSTS in a manner similar to that indicated in Fig. 4. Use extension wire as determined from Table I. Make sure that the polarities of the connections are correct.

Use well compacted melting ice baths for maintaining the temperature of the copper-to-extension wire junctions. It is permissible to use a single ice bath, provided the junctions are electrically insulated. A coating of paraffin will provide the required insulation.

Immerse the junctions at least four inches in the ice baths and allow time for them to reach ice bath temperature.

Determine the millivoltage corresponding to the low-end temperature value of the scale by referring to the proper conversion table in Directions 077989 (32 F or 0 C). This is the millivolt value required for Step 5.

Determine the millivoltage corresponding to the high-end temperature value of the scale by referring to the same table. This is the millivolt value required for Step 9.

To determine the millivolt values required for Step 12, proceed in a manner similar to that described in the preceding two paragraphs.

8. MEASURING SLIDEWIRE CONTACT FORCE ADJUSTMENTS

CAUTION: IN MAKING THE FOLLOWING CHECKS AND ADJUSTMENTS, TAKE CARE NOT TO ALLOW THE CONTACTS TO SNAP DOWN ON THE SLIDEWIRES, AS THIS MAY NICK THE SLIDEWIRES AND ADVERSELY AFFECT CALIBRATION.

The contacts should bear against their respective slidewires with a force of 2 to 3 ounces. If the contact force is too low, unreliable electrical connection may result. Excessive force will cause rapid wear of the contacts.

When a contact is disturbed or a new contact assembly installed, the contact force should be measured. To do this first rotate the slidewire drum to its high-end stop. Then use a spring scale with an L-shaped hook on its end to make the measurement. If the force (applied as radially as possible) required to just lift the contact off the slidewire is not within 2 to 3 ounces (56 to 84 grams), readjust the contact force. Excessive contact force can be relieved by bending the contact outward without removing the contact assembly from its mounting on the slidewire assembly. To increase the force remove the contact assembly from the slidewire, bend the contact as required, remount the contact assembly, and recalibrate the circuit as instructed in Section 7.

9. MAINTENANCE

The 8693 Temperature Potentiometer is designed for reliable trouble-free operation. With reasonable care in handling and use, no normal maintenance is required other than periodic replacement of the battery. Instructions for battery replacement and other less frequent maintenance procedures are given below.

A. Battery

A 1.5 volt battery is mounted in the potentiometer When it is no longer possible to standardize the potentiometer circuits, replace the battery with a new one. The battery may easily be replaced after removing the cover plate secured to the bottom of the case by a thumb screw.

CAUTION: BATTERIES SHOULD BE REPLACED AT LEAST EVERY 8 TO 10 MONTHS, REGARDLESS OF USAGE, TO MINIMIZE THE POSSIBILITY OF LEAKAGE AND RESULTING DAMAGE TO THE INSTRUMENT.

B. Cleaning the Measuring Slidewires

The slidewires may require occasional cleaning over extended periods of time, depending upon the conditions under which the potentiometer is used.

Carefully remove the control panel assembly from the case by loosening the four panel mounting screws sufficiently to disengage the fasteners. Rest the assembly on a suitable surface so that it leans on the scale setter.

Clean and lubricate the slidewire winding only with an approved cleaner-lubricant which can be obtained from Leeds & Northrup Company by ordering Part No. 124179. Do not clean the slidewire with any other lubricant or with an abrasive material.

C. Standard Cell

The standard cell may be expected to maintain correct emf for several years unless it is accidently short-circuited. If trouble encountered in calibrating the potentiometer circuits cannot be located by other tests, measure the open-circuit voltage of the cell with a precision potentiometer, such as the 7553 Type K-3 Universal Potentiometer or equivalent. Make sure that the cell is disconnected and is in its normal operating condition when making this measurement. If the open-circuit voltage is less than 1.0175 volts, the cell is unserviceable and must be replaced.

To remove the standard cell for test or replacement, proceed as follows:

Carefully remove the control panel assembly from the case. Rest it on a suitable surface so that it leans on the scale setter.

Unsolder the standard cell's red and blue leads from the bracket on which the cell is mounted.

Now remove the cell from the bracket by unwinding the tape (#33 Scotch Electrical Tape) that secures the cell to the bracket.

To replace the cell or mount a new one, reverse the procedure outlined above. Make sure that the mounting of the cell conforms to the original mounting arrangement.

D. Galvanometer

To replace the galvanometer, simply remove its two mounting screws and then withdraw it from the panel. Unsoldering of the galvanometer leads is not required, as the potentiometer is so designed that the galvanometer is disconnected from the potentiometer circuits when it is removed from the panel.

To remount the galvanometer or to mount a new one, reverse the above procedure.

Static charges on the galvanometer window may cause sporadic needle deflections. Hence it is suggested that an anti-static coating on the outside of the galvanometer window be prepared as follows:

—Dilute a small amount of "Joy" liquid soap approximately 50% by volume with tap water.

—Pour the solution over the window and allow it to drip dry.

—Lightly polish the window to remove any haze after the soap solution has dried.

E. Measuring Slidewire Contact Assemblies

At yearly intervals, or more frequently if the instrument is subjected to continuous use, inspect the measuring slidewire contact(s) for wear. The contact(s) should be replaced before the soft metal of the contact(s) is worn through. When the contact assembly is replaced (by unsoldering the lead and removing two screws), the contact pressure and instrument calibration should be adjusted as directed in Section 7.

F. Scale Window

If it ever becomes necessary to replace the scale window, first remove the knobs from the FUNCTION switch and BATTERY rheostat. Then remove the metal plate to which the window is attached. Replace the window with a new one. Then remount the metal plate and the knobs.

10. REPLACEMENT PARTS AND AUXILIARY EQUIPMENT

A. Replacement Parts

The replacement parts for the 8693 Temperature Potentiometer are listed in Table II.

TABLE II—REPLACEMENT PARTS

DESCRIPTION	PART NO.
Galvanometer	062111
Binding Post, Head	002199
Binding Post, Stud (Iron)	061469
Binding Post, Stud (Constantan)	061468
Binding Post, Stud (Copper)	061467
Function Switch	032229
Scale Window	066125
Battery Rheostat	013204
Galvanometer Key	031291
Standard Cell	130031
Slidewire Contact Assembly (Range A)	029611
Slidewire Contact Assembly (Range B)	029610
Trimmer Rheostat (S2 or S4)	013203
1-1/2 Volt Battery (Burgess 4FH or equivalent)	Std. 2233-1
Panel Mounting Screw Assembly	
Screw	4-4-1-24
Bushing	6-2-1-2
Spring, Upper	28-1-3-10
Spring, Lower	28-1-3-9
Clamp	72-4-1-1
Retaining Ring	27-3-3-12
Latch	71-1-0-1
Handle	046055
Feet	41-2-11-2

B. Auxiliary Equipment

Description	Part No.
Thermocouple Assemblies, Parts, and Accessories	See Catalog EN-S2

APPENDIX

INSTRUCTIONS FOR ORDERING

RANGE CHANGE PARTS FOR STANDARD RANGES

TABLE A1—STANDARD RANGES

TYPE OF THERMOCOUPLE	RANGE	SUFFIX NUMBER
Iron-Constantan	0 to 300 F	048
	-100 to +500 F	009
	0 to 1000 F	003
	400 to 1200 F	172
	0 to 1600 F	142
	0 to 2000 F	049
	900 to 2000 F	164
	- 50 to +105 C	513
	0 to 200 C	007
	-100 to +400 C	166
	0 to 500 C	022
	0 to 800 C	057
	0 to 1100 C	165
Chromel-Alumel	0 to 700 F	200
	0 to 1200 F	024
	0 to 2000 F	001
	0 to 2500 F	143
	1000 to 2500 F	046
	0 to 600 C	062
	0 to 1200 C	047
	500 to 1200 C	167
Plat. 10% Rhodium-Plat.	0 to 2500 F	033
	0 to 3200 F	144
	2000 to 3200 F	052
	0 to 1600 C	067
Plat. 13% Rhodium-Plat.	0 to 3200 F	145
Copper-Constantan	-340 to +230 F	168
	-100 to +400 F	032
	0 to 650 F	201
	-200 to +150 C	170
	-100 to +300 C	146
	0 to 400 C	169
Millivolts	5 to 0 to 5	084
	0 to 10	044
	0 to 25	127
	0 to 50	045

Select the appropriate suffix number of the new range from the list of standard ranges in Table A1. Add this number to the base numbers of the resistor panel and scale. Check the material of the present binding post studs by referring to Table A2; if incorrect for the new range specify the proper stud(s).

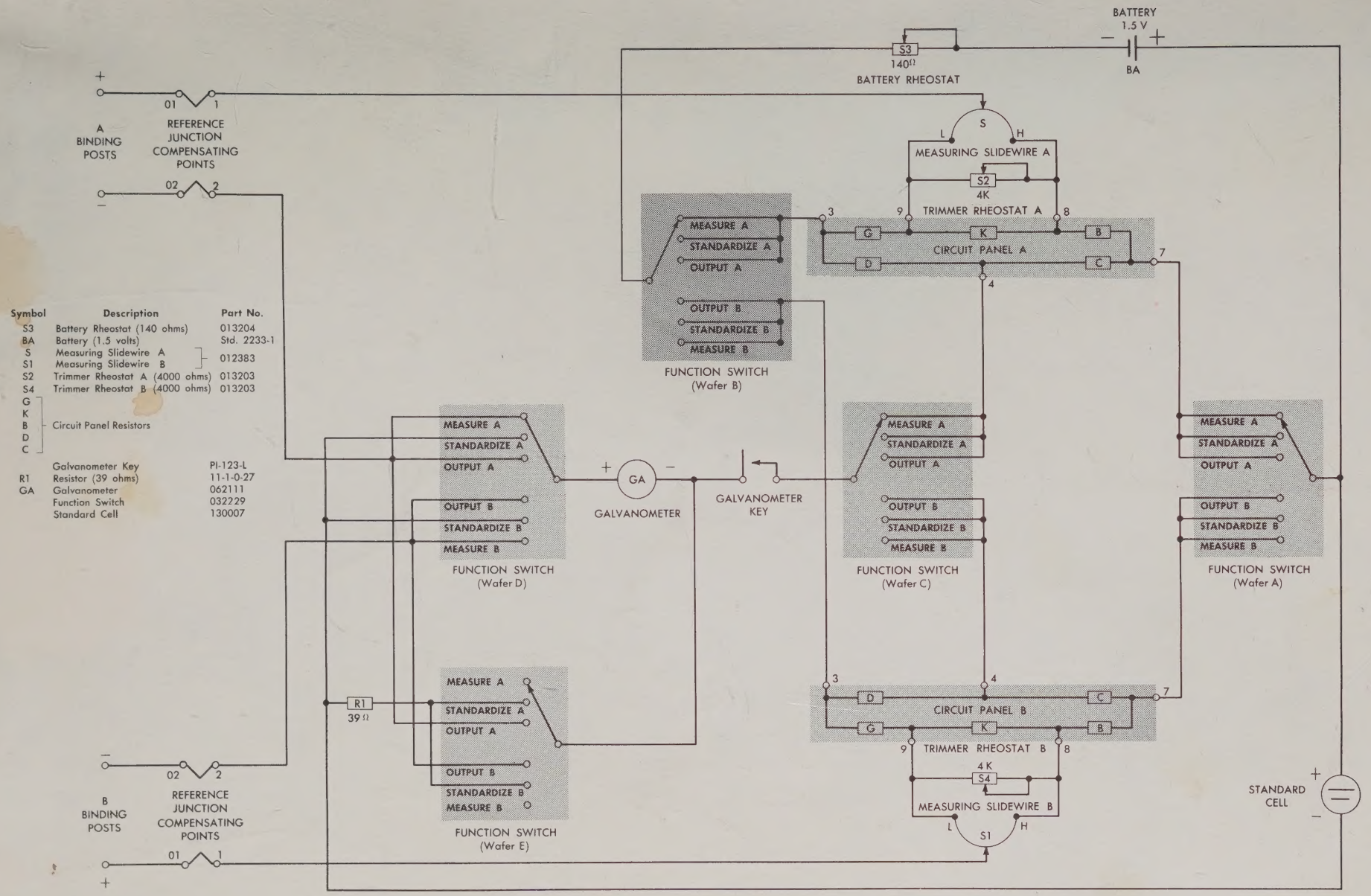
For example: Assume that the present range of the potentiometer is 0-2500 F for Plat.-Plat. 10% Rhodium thermocouples and the desired new range is 0-1000 F for Iron-Constantan thermocouples. The suffix number of the new range as determined from Table A1 is 003. The material of both present binding post studs as determined from Table A2 is copper. This material is incorrect for the new range. As determined from Table A2, the proper binding post studs for the new range are 061469 Positive (+) Stud (Iron) and 061468 Negative (-) Stud (Constantan). The order for the range change parts should therefore read as follows:

QUANTITY	PART NO.	DESCRIPTION
1	605 [0][0][3]	Resistor Panel
1	189 [0][0][3]	Scale
1	061469	Positive (+) Binding Post Stud (Iron)
1	061468	Negative (-) Binding Post Stud (Constantan)

If both ranges of the 8693 Portable Temperature Potentiometer are to be changed, two resistor panels, two scales, and required binding post studs must be specified.

TABLE A2—BINDING POST STUDS

TYPE OF THERMOCOUPLE	BINDING POST STUDS			
	Positive (+)		Negative (-)	
	Material	Part No.	Material	Part No.
Iron-Constantan	Iron	061469	Constantan	061468
Chromel-Alumel	Copper	061467	Constantan	061468
Plat.-Plat. 10% Rhodium	Copper	061467	Copper	061467
Plat.-Plat. 13% Rhodium	Copper	061467	Copper	061467
Copper-Constantan	Copper	061467	Constantan	061468
Millivolts	Copper	061467	Copper	061467



Symbol	Description	Part No.
S3	Battery Rheostat (140 ohms)	013204
BA	Battery (1.5 volts)	Std. 2233-1
S	Measuring Slidewire A	012383
S1	Measuring Slidewire B	
S2	Trimmer Rheostat A (4000 ohms)	013203
S4	Trimmer Rheostat B (4000 ohms)	013203
G, K, B, D, C	Circuit Panel Resistors	
	Galvanometer Key	PI-123-L
R1	Resistor (39 ohms)	11-1-0-27
GA	Galvanometer	062111
	Function Switch	032229
	Standard Cell	130007

Fig. 7—Schematic diagram of 8693 Portable Temperature Potentiometer.

L&N FIELD OFFICES

ALA., *Birmingham*
ARIZ., *Phoenix*
CAL., *Los Angeles* [*Monterey Park*]
CAL., *San Francisco* [*San Mateo*]
COLO., *Denver*
CONN., *Hartford* [*West Hartford*]
DEL., *Wilmington*
D.C., *Washington* [*Silver Spring, Md.*]
FLA., *Orlando*
GA., *Atlanta*
ILL., *Chicago* [*Park Ridge*]
ILL., *Lansing*
IND., *Indianapolis*
IOWA, *Davenport* [*Bettendorf*]
LA., *Baton Rouge*
MD., *Baltimore* [*Silver Spring*]
MASS., *Boston* [*Dedham*]
MICH., *Detroit* [*Oak Park*]
MICH., *Grand Rapids*
MINN., *Minneapolis*
MO., *Kansas City*
MO., *St. Louis* [*Clayton*]
NEB., *Omaha*
N.J., (*Northern*), *East Orange*
N.Y., *Albany* [*Latham*]
N.Y., *Buffalo*
N.Y., *New York*
N.Y., *Rochester*
N.Y., *Syracuse*
N.C., *Winston-Salem*
OHIO, *Canton*
OHIO, *Cincinnati*
OHIO, *Cleveland*
OHIO, *Columbus*
OHIO, *Dayton*
OHIO, *Toledo*
OKLA., *Tulsa*
OREGON, *Portland*
PA., *Allentown*
PA., *Harrisburg*
PA., *Philadelphia* [*Fort Washington*]
PA., *Pittsburgh*
TENN., *Knoxville*
TEXAS, *Dallas*
TEXAS, *Houston*
UTAH, *Salt Lake City*
VA., *Richmond*
WASH., *Seattle*
W. VA., *Charleston*
WISC., *Milwaukee*

Executive & Administrative Offices: Sumneytown Pike, North Wales, Pa. 19454
Plants: North Wales and Philadelphia, Pa.

Leeds & Northrup, Canada, Ltd., 41 Constellation Court, Rexdale (Toronto), Ontario
Field Offices: Calgary, Hamilton, Montreal

Leeds & Northrup, Ltd., Wharfdale Road, Tyseley, Birmingham 11, England
Field Offices: London, Sunderland

Leeds & Northrup Italiana, S.p.A., Via Alessandrina, 20037 Paderno Dugnano (Milano)
Field Offices: Rome, Vicenza

Leeds & Northrup Mexicana, S.A., Naucalpan de Juarez (Mexico City), Mexico
Field Office: Monterrey

Leeds & Northrup Australia Pty. Limited, 296 Botany Rd., Alexandria, N.S.W.
Field Offices: Adelaide, Brisbane, Melbourne, Newcastle, Perth, Wollongong

Agents in Principal Countries throughout the world.

Cable Address: "Leedsnorth" Bentley Code.

LEEDS & NORTHRUP

Pioneers in Precision

www.manualsplus.com

6-569

Printed in U.S.A.